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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

MISSOURI HEADWATERS BASIN
LOWER BRANHAM LAKE DAM
MADISON COUNTY, MONTANA
MT-898

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THREE CREEKS WATER COMPANY
(OWNER/OPERATOR)

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TABLE OF CONTENTS

Paragraph		Page
	EXECUTIVE SUMMARY.	i
	PERTINENT DATA	iv
	CHAPTER 1 - BACKGROUND	
1.1	INTRODUCTION.	1
1.1.1	Authority and Scope.	1
1.1.2	Purpose.	2
1.1.3	Inspection	2
1.2	DESCRIPTION OF PROJECT.	3
1.2.1	General.	3
1.2.2	Regional Geology	3
1.2.3	Seismicity	4
1.2.4	Site Geology	5
1.2.5	Design and Construction History.	5
	CHAPTER 2 - INSPECTION AND RECORDS EVALUATION	
2.1	HYDRAULICS AND STRUCTURES	6
2.1.1	Spillway	6
2.1.2	Outlet Works	6
2.1.3	Freeboard.	7
2.2	HYDROLOGY	7
2.2.1	Climatology and Physiography	7
2.2.2	Reservoir Storage and Spillway Discharge	8
2.2.3	Estimated Probable Maximum Flood	8
2.2.4	Flood Routing.	9
2.3	GEOTECHNICAL EVALUATION	10
2.3.1	Embankment	10
2.3.2	Foundation Condition, Seepage, and Drainage	10
2.3.3	Stability.	10
2.4	PROJECT OPERATION AND MAINTENANCE	11
2.4.1	General.	11
2.4.2	Dam.	11
2.4.3	Reservoir.	12
2.4.4	Warning System	12

CHAPTER 3 - FINDINGS AND RECOMMENDATIONS

3.1	FINDINGS.	13
3.1.1	Size, Hazard Classification and Safety Evaluation	13
3.1.2	Embankment Dam	13
3.1.3	Spillway	14
3.1.4	Outlet Works	14
3.1.5	Spillway and Reservoir Capacity.	14
3.1.6	Operation and Maintenance.	14
3.2	RECOMMENDATIONS	14
	REFERENCES.	16

PHOTOS

1	Upstream Face from Right Side of Reservoir	17
2	Upstream Face from Right Abutment	17
3	Downstream Face, Maximum Section and Right Abutment	18
4	Downstream Face, Maximum Section (Left Abutment beyond Trees)	18
5	Lake Outlet Channel, Upstream from Dam	19
6	Outlet Control Works	19
7	Conduit Outlet	20
8	Downstream Face from below Maximum Section	20
9	Maximum Section, Looking Downstream	21
10	Spillway Control Section, Looking Upstream	21
11	Spillway, Looking Downstream	22

PLATES

1	Site Plan & Vicinity Map
2	Dam Cross Section at Outlet
3	Dam Center Line Profile
4	Spillway Profile
5	Elevation - Area Storage Curves
6	Spillway Discharge Rating Curve
7	Outlet Discharge Rating Curve

EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers and with representation from the Corps of Engineers and the State of Montana Department of Natural Resources and Conservation, Lower Branham Lake Dam was inspected by Hoskins-Western-Sonderegger, Inc., on September 18, 1979, under the authority of Public Law 92-367. No owners or United States Forest Service representatives were present during the inspection. Lower Branham Lake Dam is located on a tributary of Mill Creek in Madison County, Montana, approximately 11 miles northeast of Sheridan, Montana. The project is in the Beaverhead National Forest and is operated by authority of a United States Forest Service permit.

This report was compiled from information obtained during an on-site inspection, a review of operation records, and analysis of hydrologic and hydraulic data. Findings were compared to engineering criteria currently accepted by most private and public agencies engaged in dam design, construction, and operation.

PRINCIPAL FINDINGS AND EVALUATION

Lower Branham Lake is intended to be used for irrigation storage and for recreation. The project consists of a natural lake and an embankment to raise the lake elevation for irrigation storage. However, the storage of irrigation water above the low level outlet is currently not permitted by the Forest Service due to the condition of the dam. The reservoir has a drainage area of 0.82 square miles, a maximum surface area of about 16 acres at the spillway crest, and storage at dam crest of 240 acre-feet. Included in the total drainage area are 0.51 square miles which drain directly into Upper Branham Lake, located approximately 1200 feet north of Lower Branham Lake. Upper Branham Lake is also a natural lake modified by the construction of a dam. Emergency spillway discharges from Upper Branham Lake flow directly into Lower Branham Lake. During the PMF, Upper Branham Lake Dam could breach, contributing more inflow to Lower Branham Lake.

In accordance with the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1), the 24-foot-high Lower Branham Lake Dam (MT-898) is classified as being of small size and as having a high (Category 1) downstream hazard potential, due to the presence of two campgrounds and more than 40 inhabitable structures below the dam. However, no dam breach and downstream flood routing analyses have been done. Projected downstream effects from dam failure are based on the visual inspection and judgment.

Inspection criteria (Ref. 1) recommend that a small-sized project with a high downstream hazard potential be capable of safely handling a flood in the range of one-half the probable maximum flood (PMF) to the PMF. The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. Considering the number of inhabitable structures within the flood path and the potential for property damage, we recommend that the project safely handle the full PMF.

An estimated PMF resulting from a generalized 72-hour storm was developed for the drainage basin. This PMF has an estimated volume of approximately 765 acre-feet, of which approximately 470 acre-feet is contributed by Upper Branham Lake. The reservoir level at the beginning of the 72-hour storm was assumed to be at the irrigation outlet invert elevation. Reservoir routing of the estimated PMF indicates that the project will overtop when approximately 33 percent of the PMF volume has entered the reservoir. Should the reservoir fill prior to the PMF due to antecedent storms and/or snowmelt, the dam could overtop even earlier in the PMF.

The dam is constructed of materials that will erode and fail when overtopped by flood waters. Such failure could endanger the lives of many people and cause considerable property damage.

On the basis of the field inspection and the study of hydrologic and operational data, Lower Branham Lake Dam does not conform to inspection guidelines with respect to discharge and/or storage capacity to safely handle the PMF. Because the project cannot safely handle 50 percent of the PMF, leading to potential loss of life and property destruction, the project is considered unsafe until the recommended actions are accomplished.

Seepage was found at the downstream toe, in the vicinity of the conduit outlet, even though no water was impounded by the dam. This water appears to be coming from holes near the downstream end of the outlet conduit. No piezometers are installed to measure water levels in the embankment, and there is no internal drainage system. The leaking conduit could eventually lead to failure of the downstream slope. It is our opinion that the embankment does not conform to the recommended guidelines with repsect to the stability of slopes (Ref. 1).

PRINCIPAL RECOMMENDATIONS

Due to storage between the normal pool (currently the elevation of the low-level inlet) and the dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

The Forest Service has prohibited the storage of water in Lower Branham Lake above the natural lake level. Extensive rehabilitation is necessary if such water is ever again to be stored.

A downstream warning plan, for use in the event of possible embankment failure, needs to be developed and placed into operation immediately. The conduit inlet structure, the trash rack, the control gate, the conduit, and the access walkway to the gate controls all need to be repaired or replaced. A formal maintenance program needs to be established.

If this project is planned for future use, the following detailed engineering studies are required. Conduct more-detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity, and modify the project as studies indicate. Perform a

stability evaluation and modify the dam to conform to inspection guidelines' stability criteria. Should the project be of no further use, safely remove the dam.

Prior to implementing report recommendations, the owner is urged to contact the U. S. Forest Service and the Montana Department of Natural Resources and Conservation.

By _____
Stephen H. Nickel
Professional Engineer

PERTINENT DATA

1. GENERAL

Federal ID. No.	MT-898
Owner	Three Creeks Water Company
Operator	Same
Purpose	Irrigation and recreation
Location	Section 5, T4S, R3W Madison County, Montana
Watershed	Mill Creek
Downstream Hazard Potential	High (Category I)
USGS Quadrangle	Waterloo, Montana Harrison, Montana

2. RESERVOIR

Surface Area (Spillway Crest)	16 acres
Normal Storage (Spillway Crest)	190 acre-feet
Total Storage (Min. Dam Crest)	240 Acre-feet
Surcharge Storage	50 acre-feet
Drainage Area	0.82 square miles
Reservoir Water Surface Elev. (9/18/79)	8732.0 feet (NGVD)

3. SPILLWAY

Type	Uncontrolled earth and rock channel
Crest Elevation	8740.0 feet (NGVD)
Crest Width	20 feet (approx.)
Spillway Capacity (Min. Dam Crest)	370 cfs

4. OUTLET WORKS

Type	Controled corrugated metal pipe with trash rack at upstream end.
Controls	Manually operated slide gate with rising stem and access catwalk.
Size, length	18-inch-diameter, 58 feet long
Inlet Invert	8729.4 feet (NGVD)
Outlet Invert	8725.5 feet (NGVD)
Normal Tailwater	Unkown
Discharge Capacity (Min. Dam Crest)	32 cfs

5. DAM

Type	Earth
Hydraulic Height	24 feet
Crest Length	280 feet
Minimum Crest Elevation	8743.5 feet (NGVD)
Crest Width	9 feet
Upstream Slope	1(V) on 2.75(H) upper 7 feet; 3-foot berm; 1(V) on 2.1(H) below
Downstream Slope	1(V) on 1.54 (H)

CHAPTER 1

BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of Lower Branham Lake Dam, owned by Three Creeks Water Company of Sheridan, Montana.

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Office of the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams," Appendix D to "Report of the Chief of Engineers on the National Program of Inspection of Dams," dated May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines recommend a two-phased study procedure for investigation and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam;
(2) based upon an evaluation of the available data and a visual inspection;
(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted; and
(4) not intended to include extensive explorations or analyses or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses and structural stability anaylses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only

to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and neither action nor failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based upon visual inspection of the project as well as interviews with owners and/or knowledgeable residents. Records of infrequent inspections dating as far back as September 1922 were furnished for reference. No design drawings or foundation exploration data were available for review or analysis. Inspection procedures and criteria were those established by the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1).

Personnel present during the inspection included:

Louis Boitano, Civil Engineer, Seattle District Corps of Engineers; and
Art Taylor, State of Montana, Department of Natural Resources and Conservation.

Hoskins-Western-Sonderegger, Inc. personnel who participated in the field inspection and contributed to this report are:

Stephen Nickel, Geotechnical Engineer, Team Leader;
Michael McMeekin, Hydrologist/Hydraulics Engineer; and
Gene Holtorf, Hydrologist/Hydraulics Engineer.

This report has been reviewed by representatives of Three Creeks Water Company, the Montana State Department of Natural Resources and Conservation, and the U.S. Forest Service. Written comments from the DNRC and the Forest Service have been included in the Appendix of this report. The owner did not comment.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Lower Branham Lake (MT-898), owned by the Three Creeks Water Company, is the southernmost of the two Branham Lakes. It is a natural lake which has been modified by the construction of a dam across the natural outlet. The lake is used for recreation and irrigation and is located on the headwaters of Mill Creek, in Section 5, Township 4 South, Range 3 West, Madison County, Montana, approximately 11 miles northeast of Sheridan.

Upper Branham Lake, the northernmost of the two lakes is located just to the northeast of Lower Branham Lake. It is also a natural lake which has been modified by construction of a dam. This dam is currently being reconstructed by the Forest Service. Principal spillway discharges from Upper Branham Lake are diverted around Lower Branham Lake; emergency spillway discharges, however, flow directly into Lower Branham Lake.

Lower Branham Lake Dam was constructed on the south side of the natural lake sometime around 1910. Lower Branham Lake has a total drainage area of 0.82 square miles, a surface area of 16 acres at the spillway crest (elevation 8740.0 feet), storage at the spillway crest of approximately 190 acre-feet, and storage at the minimum dam crest (elevation 8743.5 feet) of uncontrolled earth and rock channel. The control section is a crudely-constructed, wooden rectangular weir with a 20-foot-wide crest. The spillway exit channel leads to Mill Creek. An 18-inch corrugated metal pipe with a manually controlled slide gate at the inlet is located near the upstream toe of the embankment and is used for releasing irrigation water and controlling the lake level. At the time of the inspection, the slide gate was partially open, limiting the storage of water to that retained below the low-level outlet invert. Impoundment of water behind the dam has been disallowed since 1975 when the U. S. Forest Service condemned the dam due to its deteriorated condition and lack of adequate maintenance.

how far open

Based upon visual reconnaissance and engineering judgment, 5 cabins, 2 campgrounds, 35 dwellings, and most of the City of Sheridan (population 640), located approximately 12 miles downstream, could be affected by a sudden breach of the dam. On the basis of this information and in accordance with the recommended guidelines (Ref. 1), the project is small and the downstream hazard potential classification is high.

1.2.2 Regional Geology

Lower Branham Lake Dam is situated high on the western flank of the Tobacco Root Mountains. The Tobacco Root Mountains are bounded on the north by the Jefferson River Valley, on the east by the Madison River Valley, on the west by the Beaverhead River Valley, and on the south by the Gravelly-Greenhorn Mountain Ranges.

The Tobacco Root Mountains have an igneous batholitic intrusion as a core with older metamorphic and sedimentary rocks mantling the igneous core. Associated with igneous intrusion, but not contemporaneous, is the

structural development of the mountains by block faulting and thrust faulting. Present surficial sediments have a glacial origin at higher elevations and near the valley floor, in the lower elevations, are loosely consolidated (valley-fill) sediments.

1.2.3 Seismicity

Lower Branham Lake Dam, located in the Tobacco Root Mountains, lies in Seismic Zone 3 as indicated by the Seismic Zone Map (Ref. 1). The seismic probability of this regional setting is one of potential for major damage and is based on the known distribution of damaging earthquakes in the region.

The preliminary Map of Young Faults in the United States, by the U.S. Geological Survey (Ref. 2), indicates suspected activity along the northwestern expanse of the Tobacco Root Mountains during Holocene time. Major faulting has also occurred prior to the Cenozoic in the western and northern regions of the Pioneer Mountains according to the Montana State Geologic Map.

Epicenters of local earthquakes significant enough to be reported in References 3 and 4 occur to the north-northeast along a line from 20 miles northwest of Helena to 25 miles north of Bozeman, and to the southeast in northeast Idaho, northwest Wyoming, and the adjoining areas of Montana. Two earthquakes of significant intensity that occurred in this tri-state region were the Hebgen Lake, Montana, earthquake (8 August 1959), that had an intensity of X (Modified Mercalli), and another southeast of Dillon, Montana, and south of the project area (23 November 1947), that had an intensity of VIII. The three largest reported earthquakes northeast of the Tobacco Root Mountains have had intensities of VIII. One of these earthquakes had its epicenter at a point 25 miles north of Bozeman, (27 June 1925), while the other two occurred at Helena, (18 October and 31 October 1935). The epicentral area north-northeast of the project site is at a distance of 40-75 miles, while that to the south-southeast is 20-70 miles.

In the vicinity of the project, there have been numerous other earthquakes in this century (Ref. 3 and 4). In an area bounded by the 44th and 46th parallels and by the 110th and the 112th meridians (including the tri-state region), there have been more than 50 earthquakes with intensities of V and more than 10 with an intensity of VI. The closest reported earthquakes to the project site have occurred near Ennis and Virginia City. The largest of these had an intensity of VI and occured near Ennis (10 March 1977). The exact distance from the epicenter of this earthquake to the project site is not known.

The Tobacco Root Mountains lie in a seismically active area with the potential for a damaging earthquake. This warrants that special attention be given to the dams in the area that have been constructed without consideration given to the effects of earthquakes.

1.2.4 Site Geology

Lower Branham Lake lies at the junction of an igneous intrusive sill and the Precambrian metamorphic and sedimentary rocks. The drainage varies from a steeply-sloping (40-60%) headwall on the north, to a subdued cirque basin with moderate, dissected, concave slopes. Some mass-wasting features, such as talus slopes, are evident along the steeper headwall and trough-walls. A thin to moderate soil cover, probably morainal, exists on an igneous bedrock.

1.2.5 Design and Construction History

Although design and construction records for Lower Branham Lake Dam are not available, inspection records indicate that the original dam was constructed around 1910 by the Forest Service and/or local land owners. Visual inspection and data from the records indicate that the dam is of earth fill construction with a concrete core. These records state that the structure failed and was repaired in 1916, 1922, and 1950 and required various degrees of maintenance numerous other times. In 1916 a 50-foot section of the dam was washed out. This was corrected by the construction of a 1-foot-thick, reinforced concrete core, extending 25 feet either direction from the outlet pipe. Failures in 1922 and 1950 were due to large holes in the embankment which in both cases developed at the edge of the concrete core. These repairs were accomplished by the permittee under the guidance of the Forest Service.

The original design and construction history of Upper Branham Lake Dam is not known. At the time of inspection, the dam was breached. Reocnstruction of the dam, however, was begun in the fall of 1979 with completion scheduled for the summer of 1980. Design plans and specifications for the reconstruction were provided by the Forest Service. The work to be performed will include construction of a principal spillway, improvements to the emergency spillway, and rehabilitation of the embankment. Discharges into Lower Branham Lake will be unchanged. Principal spillway discharges are diverted around Lower Branham Lake, but emergency spillway discharges flow directly into Lower Branham Lake.

CHAPTER 2

INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillway

The spillway is located upstream of the right abutment of the dam and discharges into Mill Creek. The spillway is an uncontrolled earth and rock channel, with a rectangular weir 20 feet wide and 2 feet deep made of deteriorating timber. The weir is located at the spillway crest, approximately 200 feet downstream from the edge of the lake at the time of the inspection. The spillway channel upstream of the weir has a relatively regular surface covered with small rocks and gravel. Approximately 20 feet upstream of the weir, the spillway channel flattens and becomes undefinable. The log boom, located just upstream of this point, is in a deteriorating condition, with rotting and missing logs. The general slope of the upstream channel varies from zero to 11 percent. The channel downstream of the weir has a maximum depth of 4 feet, an approximate bottom width of 6 feet, and bank-to-bank width of about 25 feet. The channel is quite irregular, filled with boulders and debris. The slope of the downstream channel from the weir averages 6 percent. The spillway channel is shown in Photos 10 and 11, and the profile and typical cross sections can be seen on Plate 4.

The spillway channel appears to be in generally good condition with no serious erosion damage. Some sloughing of the banks in the downstream channel has occurred (see Photo 11), but the spillway is sufficiently removed from the dam such that the dam will not be affected.

The discharge rating for the emergency spillway was computed by assuming critical depth at the weir crest and computing water surface profiles upstream into the reservoir. The capacity of the spillway varies from zero cubic feet per second (cfs) at the spillway crest elevation of 8740.0 feet to 370 cfs at the minimum dam crest elevation of 8743.5 feet. A complete discharge rating curve for the spillway is shown on Plate 6.

2.1.1 Outlet Works

An irrigation outlet is located at the approximate center of the dam. The outlet consists of a 58-foot-long, 18-inch-diameter corrugated metal pipe running through the dam and discharging to a man-made "V" ditch leading to a tributary of Mill Creek. The outlet is controlled by a vertical slide gate located at the upstream end of the pipe and operated from the top of the gate support by a handwheel lift. The wooden catwalk to the manual control wheel has collapsed. At the time of inspection the slide gate was partially open and could not be opened or closed completely. At the upstream end of the pipe is a hand-made trash rack of logs and rebar. The flowline of the upstream end of the pipe is at an elevation of 8729.4 feet or 14.6 feet below the dam crest. The irrigation outlet works are shown

how far

in Photos 6 and 7 and on Plate 2.

The control slide gate and appurtenances are in a deteriorated state. As previously mentioned, the access catwalk has collapsed. The 18-inch corrugated metal pipe is rusted and has several holes. There also appeared to be some misalignment in the conduit from approximately the dam center line to 30 feet upstream of the outlet.

The capacity of the irrigation outlet pipe, assuming the water level to be at the minimum crest elevation of the dam, was computed as 32 cubic feet per second (cfs). This capacity was based on inlet control, with the slide gate in the fully-opened position. The complete outlet discharge rating curve can be seen on Plate 7.

2.1.3 Freeboard

The vertical distance between the water surface and the minimum dam crest at the time of inspection was 11.5 feet. Since the Forest Service has, for some time, disallowed any storage in Lower Branham Lake due to the poor condition of the dam, the normal pool for the past several years has probably been the same as that observed during the inspection. However, recent high water marks on the posts of the gate tower indicate 4- to 5-foot fluctuations during periods of high runoff (see Photo 6). The vertical distance between the spillway crest and the minimum dam crest is 3.5 feet. However, since the dam overtops during the PMF, it has no freeboard.

The effective fetch distance for wind-generated waves is approximately 0.17 miles. The total of wave run-up and wind set-up is approximately 1.6 feet (Ref. 5). Thus, the vertical distance between the minimum dam crest elevation and the wave height elevation (assuming normal pool at the minimum crest of the spillway) is adequate to prevent overtopping by wind-generated waves (Ref. 6).

2.2 HYDROLOGY

2.2.1 Climatology and Physiography

The climate of the area around Lower Branham Lake is continental and characterized by a large diurnal and seasonal temperature range. Extreme variability of wintertime temperatures results from the frequent occurrence of chinook winds. The summers are characterized by warm days with low humidity and cool nights. Winters are moderately cold and highly variable in severity from year to year and within a given year.

Pony, in Madison County, at an elevation of 5500 feet, is the climatological station nearest the damsite, with precipitation and climatological data available for approximately 20 years. The average annual precipitation at Pony is approximately 17 inches, with over 65 percent of the precipitation falling from March through August. However, by contrast, at Lower Branham Lake (elevation 8740 feet), the annual precipitation averages 45 inches

(Ref. 7). Also, at Lower Branham Lake, the average expected date of the first freeze is August 28th, and the average expected date of the last freeze is June 29th (Ref. 8).

The total drainage area above and including Lower Branham Lake is approximately 0.82 square miles, of which 0.51 square miles drains into Upper Branham Lake. There are no perennial tributaries draining into the lake. Basin elevations range from the spillway crest elevation of 8740.0 feet to approximately 9920 feet at the drainage divide. Basin vegetation consists of moderately thick pine and sparse grasses on the lower basin area, to sparse pine on extremely rocky surfaces on the upper basin area.

2.2.2 Reservoir Storage and Spillway Discharge

As previously stated, the owner has not been allowed to store water due to a lack of proper maintenance and deterioration in the condition of the dam. However, should the dam be restored, the lake would have a surface area of about 16 ares and a storage of 190 acre-feet at the spillway crest elevation of 8740.0 feet. Approximately 50 acre-feet of storage are available between this spillway crest and the minimum dam crest elevation of 8743.5 feet. Discharge through the spillway with the reservoir at the minimum dam crest is approximately 370 cfs. Also under these conditions, an additional 32 cfs of discharge would occur through the irrigation outlet, if the control gate were in the fully-opened position. Complete stage-area and stage-storage curves for the lake are shown on Plate 5. Complete discharge rating curves for the spillway and irrigation outlet are shown on Plates 6 and 7, respectively.

2.2.3 Estimated Probable Maximum Flood

The probable maximum flood (PMF) is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The probable maximum precipitation (PMP) was derived in the following manner: the 24-hour, 12-hour, 6-hour and 1-hour PMP depths were estimated from U. S. Weather Bureau Technical Paper #38 (Ref. 9) to be 15.2 inches, 13.2 inches, 11.2 inches, and 7.1 inches, respectively. The 48-hour and 72-hour PMP depths were taken as 110 percent and 115 percent of the 24-hour PMP, or 16.7 inches and 17.4 inches, respectively. All 6-hour increments were arranged in a critical order of occurrence using criteria presented in the U. S. Weather Bureau Hydrometeorological Report No. 43 (Ref. 10).

The probable maximum flood was assumed to result from a PMP storm in the late spring over frozen ground. Thus, a constant soil loss rate of zero was applied throughout the 72-hour PMP storm, in accordance with Corps of Engineers recommendations. Thus, the overall configuration of the 72-hour storm is not affected by losses in the soil, and the basin rainfall is equal to the basin runoff for all storm increments. Direct precipitation onto the surface of the lake also was added in with no losses.

In evaluating the PMF for Lower Branham Lake, inflow from Upper Branham Lake also was taken into account. The same 72-hour storm was applied to the Upper Branham Lake drainage basin. Soil losses were again assumed to be zero.

2.2.4 Flood Routing

The lake level at the beginning of the 72-hour storm was assumed to be at the irrigation outlet invert elevation of 8729.4 feet. This corresponds to the present normal pool condition with the lake drawn down and no storage allowed. Routing the PMF beginning with the reservoir at the outlet invert elevation is the most optimistic condition that could occur. Therefore, this routing shows better project performance than would actually occur under PMF conditions when the water level would be higher.

Inflows to Lower Branham Lake from nearby Upper Branham Lake were also considered in the PMF evaluation. Initial reservoir conditions assumed for Upper Branham Lake were similar to those for Lower Branham Lake. Upper Branham Lake Dam was assumed to fail, or breach, at the time that the reservoir level reached the top of the dam. As has been previously stated, principal spillway discharges from Upper Branham Lake are diverted around Lower Branham Lake. During the PMF, however, the small diversion channel could not handle the large flows from the principal spillway and from a breach of the dam. Overflow from the diversion channel will follow the natural drainage pattern of the area and flow into Lower Branham Lake. All discharges from Upper Branham lake were, therefore, combined with the inflow from the Lower Branham Lake drainage area. The evaluation of Upper Branham Lake was based on the plans for reconstruction of the dam obtained from the Forest Service.

The total volume of the 72-hour PMF for Lower Branham Lake, including inflow from spillway flow and a breach of Upper Branham Lake, is 765 acre-feet. Reservoir routings indicate that, with the control gate of the irrigation outlet closed, the reservoir will handle approximately 33% of the PMF volume before overtopping. Antecedent storms and/or snowmelt could fill the reservoir to some level prior to the PMF and, therefore, decrease the reservoir's ability to handle the PMF. The 33 percent is therefore considered as an upper limit with the understanding that more detailed studies would likely yield a failure at a lesser percentage of the PMF. However, modifications to Upper Branham Lake to prevent discharge to Lower Branham Lake could greatly increase Lower Branham Lake's ability to handle the PMF.

PMF hydrographs were developed using the SCS dimensionless unit hydrograph. Reservoir routings of the inflow hydrographs were made using the modified Puls method. The HEC-1 (Dam Safety Version) computer program (Ref. 11) was used for the hydrograph computations and reservoir routings.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Embankment

The 24-foot-high earth and rockfill dam is 280 feet long and has a crest width of 9 feet. Records show that the embankment may have a concrete core wall. The upstream slope is 1(V) on 2.75(H) for the upper 7 feet, a 3-foot berm at elevation 8736.7 feet, and 1(V) on 2.1(H) below the berm. The downstream slope is 1(V) on 1.54(H). Borrow for the embankment was obtained locally, perhaps with a portion coming from borrow areas immediately upstream from both abutments. The material exposed on the upstream face and on the crest is a sandy silt, with very little clay and containing gravel and cobbles. The sandy silt embankment soil is considered to be highly erosive. The downstream portion of the embankment is composed of clean, angular rock, ranging up to 30-inch size. The thickness of this rock zone is not known, but it appears to be at least 5 feet thick at the downstream toe.

The only vegetated areas of the embankment are on the upstream face, above and below the riprap. The vegetation consists of approximately 50% coverage of native grasses. The riprap is metamorphic rock, concentrated near the elevation of the spillway. Some rock is lying at the toe of the upstream slope, apparently transported by wave action. Embankment erosion through the riprap is not apparent, although no evidence of a granular bedding or filter course was found. The riprap appears to be inadequate, although there is very little evidence of wave erosion.

Many rodent holes were found on the upstream face of the dam.

2.3.2 Foundation Condition, Seepage, and Drainage

The dam is probably founded on soil similar to that used in the embankment itself. This material is considered to be quite pervious. The lack of extensive seepage, even if only from the natural lake, is additional evidence of a possible concrete cutoff wall.

The only seepage found was in the vicinity of the conduit outlet. At the time of the inspection, the quantity of water emerging near the toe of the embankment, below the conduit outlet, was about 2 to 4 gallons per second. This is approximately the same as that emerging from the pipe itself (see Photo 7). At least some of this water was leaking from visible holes in the conduit invert.

There is no evidence to indicate that the dam contains any type of internal drain, nor are there any piezometers installed in the dam.

2.3.3 Stability

It appears that Lower Branham Lake Dam has not stored water above the natural lake level for several years, except during high runoff periods that exceeded the capacity of the outlet works. Even under these conditions,

with no water against the upstream face of the embankment, there is still a considerable amount of seepage at the downstream toe. The source of this seepage water appears to be holes in the conduit invert, near the downstream end of the conduit. Because this water is emerging in the downstream rockfill zone and does not now appear to be eroding fines from the foundation, there is no immediate threat to the stability of the embankment. However, the leaking conduit could eventually cause failure of the downstream slope. For this reason, and because of the steep downstream slopes, it is our judgment that the stability of the embankment does not conform to inspection guidelines (Ref. 1).

2.4 PROJECT OPERATION AND MAINTENANCE

2.4.1 General

Operation and maintenance of Lower Branham Lake and Dam is the responsibility of the Three Creeks Water Company, with technical assistance provided by the Forest Service. Although a plan for operation and maintenance of the lake and dam facilities was not available at the writing of this report, inspection reports for the years 1922, 1923, 1941, 1950, 1951, 1956, and 1961 to the present infer the above repsonsibilities. In addition, the reports indicate a history of maintenance problems with the dam and a lack of any adequate maintenance since 1964.

2.4.2 Dam

There is no formal plan for performing periodic maintenance on Lower Branham Dam. Inspection reports since 1922 indicate a general lack of any adequate maintenance except that performed on an infrequent piecemeal basis. In addition, these records also indicate that the dam underwent some degree of failure and repair in 1916, 1922, and 1950 as described in Section 1.2.5.

At this writing, the dam is badly in need of maintenance. Although upstream slope riprap appears to be inadequate in both thickness and coverage, only minor wave erosion has occurred near the top of the embankment. The downstream slope of the embankment is rockfill. A significant amount of seepage (roughly 150 gallons per minute) was noticed emerging from the rock below and to the right of the irrigation pipe outlet. Weeds and moss were found growing along the outlet channel below the conduit outlet (see Photo 8). This could be evidence of seepage or a result of the wet environment caused by spray. The crest of the dam is very uneven, with many depressions and wheel ruts. There is a major sag in the crest approximately over the irrigation outlet (see Plate 3). Numerous rodent burrows were noted on the upstream face of the dam.

In general, the embankment is deteriorating due to lack of adequate maintenance and would constitute a hazard if used in its present condition to impound water. However, the impoundment of water above the natural lake level has been restricted by the Forest Service since 1975.

2.4.3 Reservoir

As previously mentioned, the Forest Service has disallowed the storage of water in Lower Branham Lake above the natural lake level. This decision was made due to the deterioration of the dam. However, high water marks on the gate support tower indicate that the water level in the lake occasionally reaches as high as 4-5 feet above the flowline of the irrigation outlet invert even though the gate is left partially open. As with the dam structure, the reservoir has no formal plan for operation and maintenance and has received very little attention for many years. A small amount of debris can be found scattered along the shoreline and in the spillway channel.

Recreation users visit the dam daily, except in the winter. Irrigation users no longer regularly visit the project.

2.4.4 Warning System

There is no formal warning system or plan of action to warn downstream inhabitants or interests in the event of impending dam failure.

CHAPTER 3

FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of Lower Branham Lake Dam, supplemented by analysis of the project in terms of the recommended guidelines' performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification and Safety Evaluation

According to the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1), Lower Branham Lake Dam is classified as small in size with a high downstream hazard potential classification. The recommended spillway design flood (SDF) for this project is 100% of the probable maximum flood (PMF). The project can safely control only 33% of the 72-hour PMF. Because the project is incapable of controlling one-half of the PMF without overtopping and causing the dam to fail, Lower Branham Lake Dam is considered unsafe until recommended actions are completed. The general deteriorated condition of the dam and holes in the outlet pipe are also of major concern.

3.1.2 Embankment Dam

Since this dam has not retained a permanent pool for several years, no seepage was anticipated to be found. However, a considerable amount of seepage was evident at the toe of the embankment in the vicinity of the conduit outlet. This seepage appears to be coming primarily from holes in the conduit invert. There have been no apparent efforts to control the seepage. No drains are included in the embankment or the foundation. In general, despite the seepage, the embankment appears to be in good condition, and all appurtenances appear to be in poor condition.

The embankment crest is not level and varies as much as 0.9 feet in elevation. The lowest points on the crest occur near the abutments (see Plate 3).

There is no instrumentation, such as piezometers, installed in the dam.

Under the present operating conditions, with no water against the dam, the embankment is not subjected to steady state seepage conditions, except those resulting from the conduit leaks. The upstream slope is not subjected to prolonged saturation which could cause instability when the reservoir is drawn down. If the project is to maintain a pool against the dam and irrigation releases are reinstated, the leaking conduit could lead to failure of the dam. In addition, the normal pool phreatic surface cannot be predicted at this time, and embankment material strengths are not known. It is our judgment that the stability of the embankment does not conform to inspection guidelines (Ref. 1).

3.1.3 Spillway

The uncontrolled earth and rock channel spillway was found to be in good structural condition, with no serious erosion damage. Some sloughing of the banks in the downstream channel has occurred, but will not endanger the dam. Debris, such as logs, boulders, and brush, litter the channel, primarily downstream from the control section. Both the log boom and the rectangular weir at the crest are badly deteriorated.

3.1.4 Outlet Works

The irrigation outlet works were found to be in poor condition. The improvised trash rack was nonfunctional, the control gate, frame, and the 18-inch-diameter conduit are corroded, and the gate does not open and close properly. The access catwalk to the gate tower has collapsed, making the gate tower accessible only by ladder. The 18-inch irrigation conduit has several noticeable holes, and water was seeping from below and to the right of the perimeter of the conduit outlet.

3.1.5 Spillway and Reservoir Capacity

The lake storage capacity and spillway discharge capacity are insufficient to prevent overtopping during the estimated PMF. This investigation has estimated that during the 72-hour PMF, the dam overtops when only 33% of the PMF volume enters the reservoir.

3.1.6 Operation and Maintenance

Operation and maintenance are the responsibility of the Three Creeks Water Company, with technical assistance provided by the Forest Service. There is no formal operation plan for the reservoir. The reservoir is not currently being used for storage due to a U.S. Forest Service order as previously mentioned. However, stream flow which exceeds the capacity of the low-level outlet is temporarily detained. In the past, the reservoir has been used for irrigation storage, being filled in the spring and having irrigation releases throughout the growing season.

There is no formal maintenance plan for the dam, and the facility has a history of inadequate maintenance. The poor condition of the outlet control works and access walkway, the many rodent holes, and the deterioration of the spillway log boom and rectangular wooden weir are all indications of the absence of maintenance by the owner for several years as substantiated in Forest Service inspection reports.

There is no formal warning system or plan of action to warn downstream inhabitants in the event of impending dam failure.

3.2 RECOMMENDATIONS

Due to storage between normal pool and dam crest, the present project

provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection. The following recommendations are predicated on the project being restored to a useable, safe condition and the impoundment of water for the intended purposes. If there is no further need for impounding water above the natural lake level, the dam should be safely removed without delay and a safe, natural lake outlet reestablished.

1. Immediately develop, implement, and periodically test an emergency warning plan for use in the event of dam overtopping or structural failure.

2. Eliminate rodent populations on the embankment and repair existing rodent damage.

3. Repair or replace the conduit inlet structure, the trash rack, the control gate, the conduit, and the access walkway to the gate tower.

4. Repair or replace the log boom and the wooden control weir in the spillway channel, and remove boulders and debris from the vicinity of the control weir.

5. Conduct more-detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity. Include Upper Branham Lake Dam in these studies. Modify the project as studies indicate.

6. Conduct engineering studies to determine the stability of the embankment. Recommended studies, to be performed by an experienced dam engineer, should include:

   - Sampling and testing of soils in the embankment and foundation;
   - Installation, maintenance, and evaluation of piezometers in the embankment, the abutments, and along the downstream toe.

   In accordance with the results of the engineering studies, modify the embankment, as required, to establish adequate factors of safety.

7. Develop and implement a periodic maintenance plan for the dam and appurtenant structures.

8. Establish a program for periodic, comprehensive, safety inspections at no more than 5-year intervals. These inspections should be performed by engineers qualified in the design, construction, operation, and maintenance of earth dams.

Prior to implementing any report recommendations, the owner is urged to coordinate with the U. S. Forest Service and Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

REFERENCES

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3. U. S. Geological Survey, "Earthquake Information Bulletin", Washington D. C., 1973-1978.

4. U. S. Department of Commerce, Earthquake History of the United States, Publication 41-1, Washington D. C.

5. U. S. Army Corps of Engineers, Office of the Chief of Engineers, "Wave Run-up and Wind Set-up on Reservoir Embankments", Engineer Technical Letter No. 1110-2-221.

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10. U. S. Department of Commerce, Environmental Science Services Administration, Weather Bureau, Probable Maximum Precipitation, Northwest States, Hydrometeorological Report No. 43, U. S. Government Printing Office, Washington, D. C. 1966.

11. U. S. Army Corps of Engineers, The Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations, Davis, California, September 1978.

(PHOTO 1) Upstream Face from Right Side of Reservoir

(PHOTO 2) Upstream Face from Right Abutment

(PHOTO 3) Downstream Face, Maximum Section and Right Abutment

(PHOTO 4) Downstream Face, Maximum Section
(Left Abutment beyond Trees)

(PHOTO 5) Lake Outlet Channel, Upstream from Dam

(PHOTO 6) Outlet Control Works

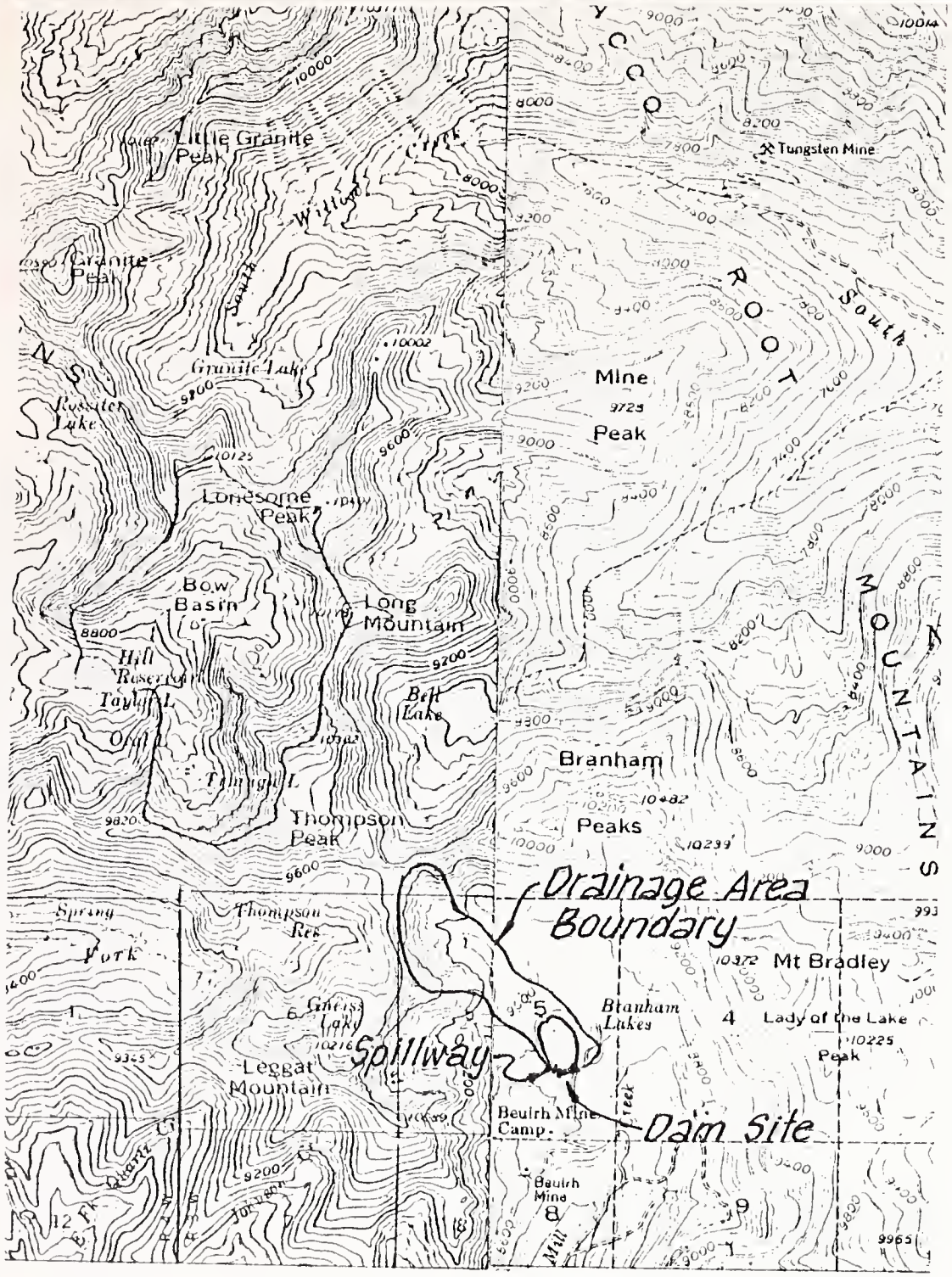
(PHOTO 7) Conduit Outlet

(PHOTO 8) Downstream Face from below Maximum Section

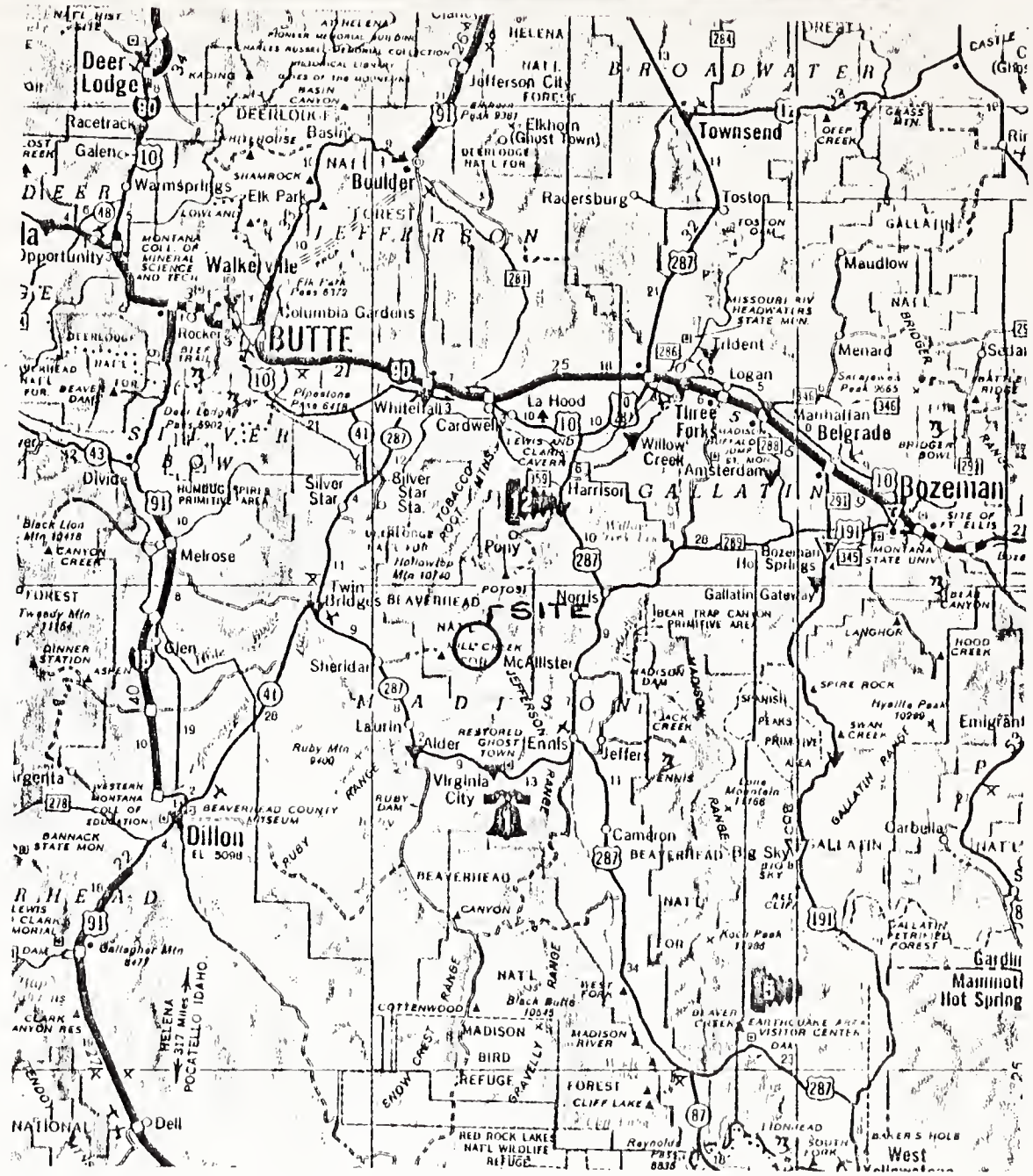
(PHOTO 9) Maximum Section, Looking Downstream

(PHOTO 10) Spillway Control Section, Looking Upstream

(PHOTO 11) Spillway, Looking Downstream



SITE PLAN


Deer Lodge
Racetrack
Galen
Warmsprings
Opportunity
Walkerville
Columbia Gardens
BUTTE
Divide
Melrose
Silver Star
Silver Star Sta.
Whitehall
Cardwell
Jefferson City
Elkhorn (Ghost Town)
Boulder
Radersburg
Townsend
Toston
Trident
Logan
La Hood
Willow Creek
Three Forks
Manhattan
Belgrade
Maudlow
Menard
Amsterdam
Harrison
Bozeman
Bozeman Hot Springs
Gallatin Gateway
Pony
Norris
McAllister
Sheridan
Twin Bridges
Laurin
Alder
Ennis
Virginia City
Jeffers
Camdron
Big Sky
Garbella
Dillon
EL 5098
Beaverhead
Canyon
Cottonwood Range
Madison Bird Refuge
Madison River
Forest Cliff Lake
Red Rock Lakes Natl Wildlife Refuge
Dell
Lionhead
Earthquake Area Visitor Center
Gardiner
Mammoth Hot Springs
West Yellowstone
Helena
Pocatello Idaho
317 Miles
Gallatin Petrified Forest
Spire Rock
Emigrant
Hyalite Peak 10299
Gallatin Range
Madison Range
Ruby Mts
Ruby Dam
Gallagher Mtn
Black Butte
Koch Peak
Lionhead
Reynolds Pass
Big Sky
Montana State Univ
Bear Trap Canyon Primitive Area
Spanish Peaks Primitive Area
Lewis and Clark Caverns
Tobacco Root Mts
Humbug Primitive Area
Beaverhead County Museum
Western Montana College of Education
Bannack State Mon
Lewis and Clark Memorial Dam
Clark Canyon Res
Hidden Lake
Hollowtop Mtn 10740
Black Lion Mtn 10418
Twodot Mtn 11164
Gallatin
Madison
Jefferson
Beaverhead
Big Hole
Rhyolite
Potosi
Site
Canyon Creek
Hood Creek
Langhor
Madison Dam
Jack Creek
Swan Creek
Bear Canyon
Deep Creek
Grass Mtn
Missouri River Headwaters State Mon
Lewis and Clark Trail
Deerlodge Natl For
Beaverhead Natl For
Gallatin Natl For
Custer Natl For
Targhee Natl For
Bridger
Bridger Bowl
Battle Ridge
Sacajawea Peak 9665
Ski Area
Rocker Ski Trail
Pipestone Pass 6418
Elk Park Pass 6170
Homestake Pass 6902
Fish Trap Lake
Hebgen Lake
Quake Lake
Earthquake Lake
Madison Arm
Hebgen Dam
Hebgen Lake Natl Wildlife Refuge
Reynolds Pass 6838
Lionhead 11166
Koch Peak 11088
Black Butte 10045
Gallagher Mtn 8677
Elk Park 6170
Pipestone Pass 6418

DAM CROSS-SECTION AT OUTLET
Lower Branham Lake Dam
Montana

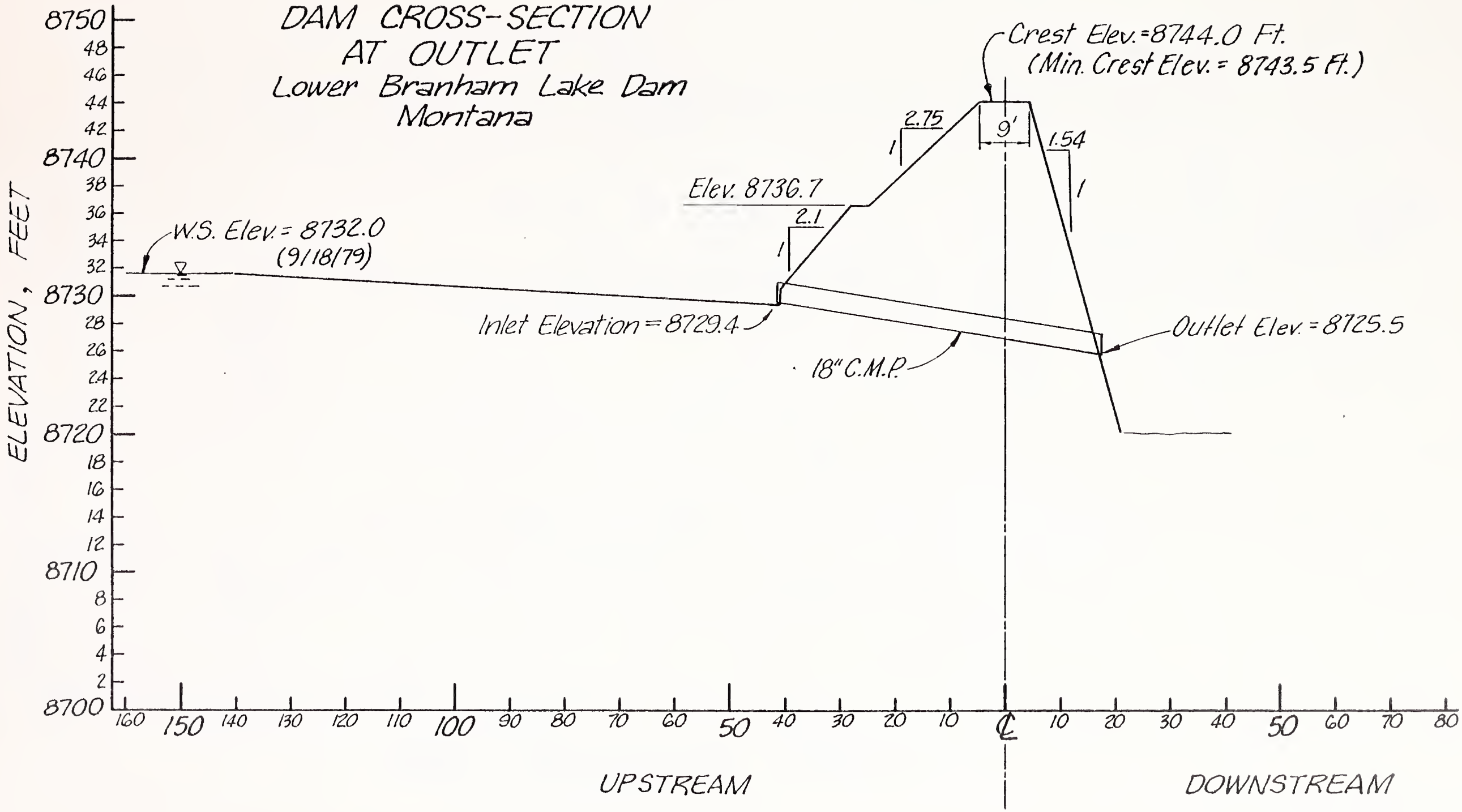
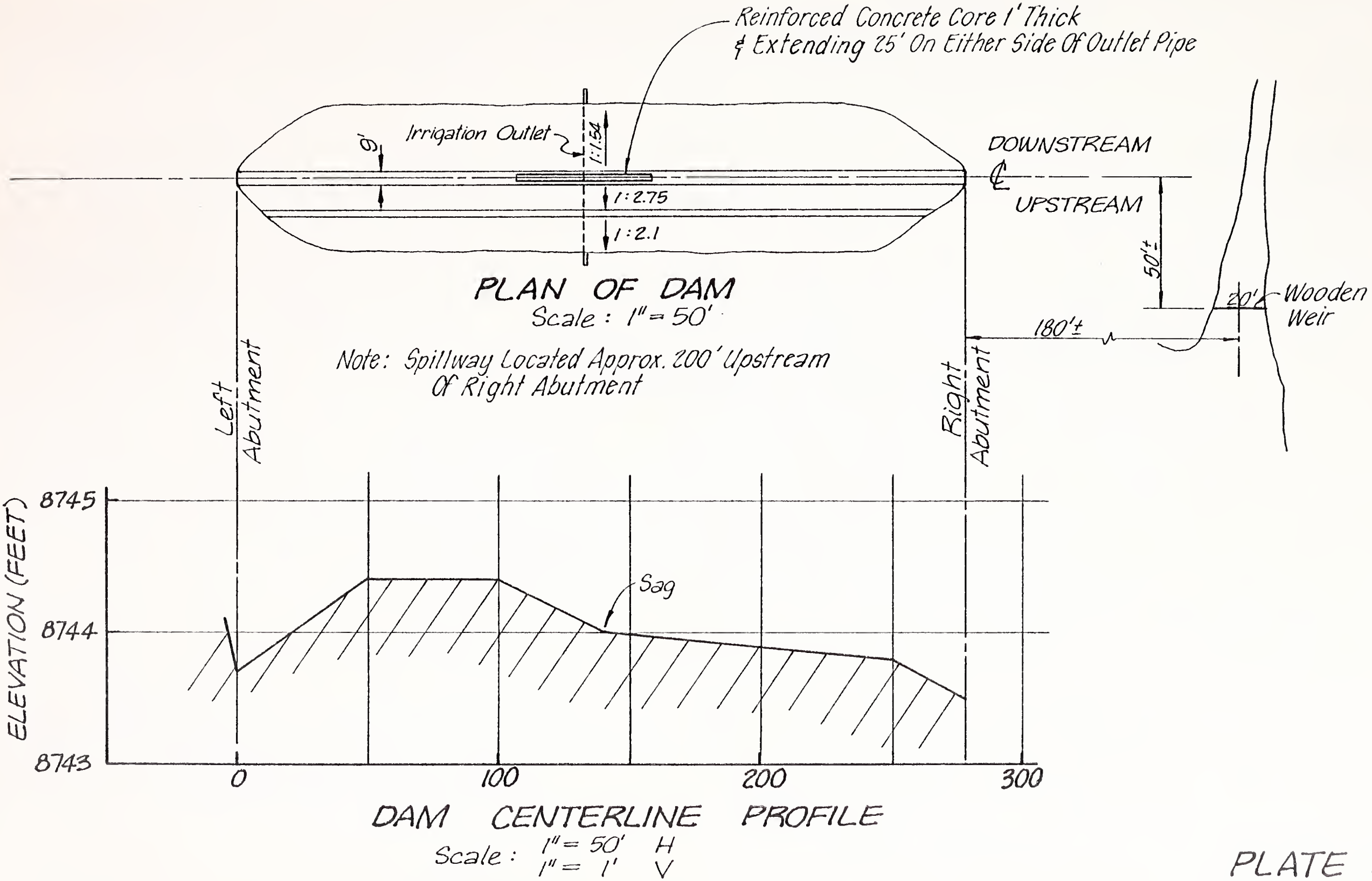


PLATE 2

Lower Branham Lake Dam
Montana

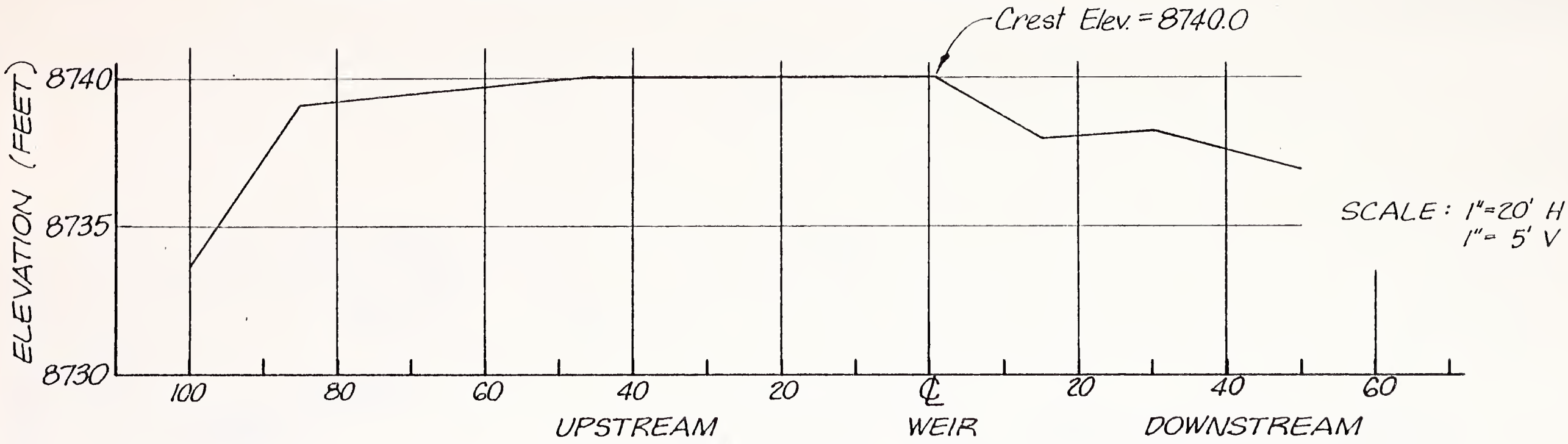


PLAN OF DAM
Scale : 1" = 50'

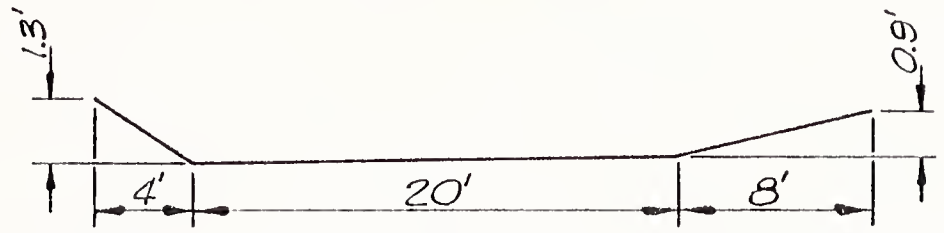
DAM CENTERLINE PROFILE
Scale : 1" = 50' H
1" = 1' V

PLATE 3

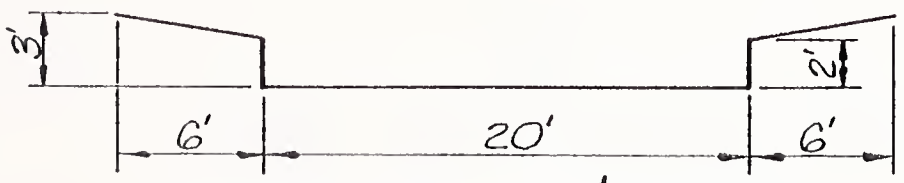
LOWER BRANHAM DAM SPILLWAY



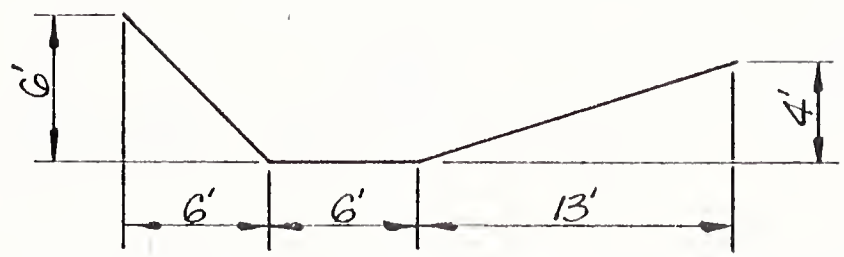
SPILLWAY PROFILE



TYPICAL X-SECTION UPSTREAM FROM S/W

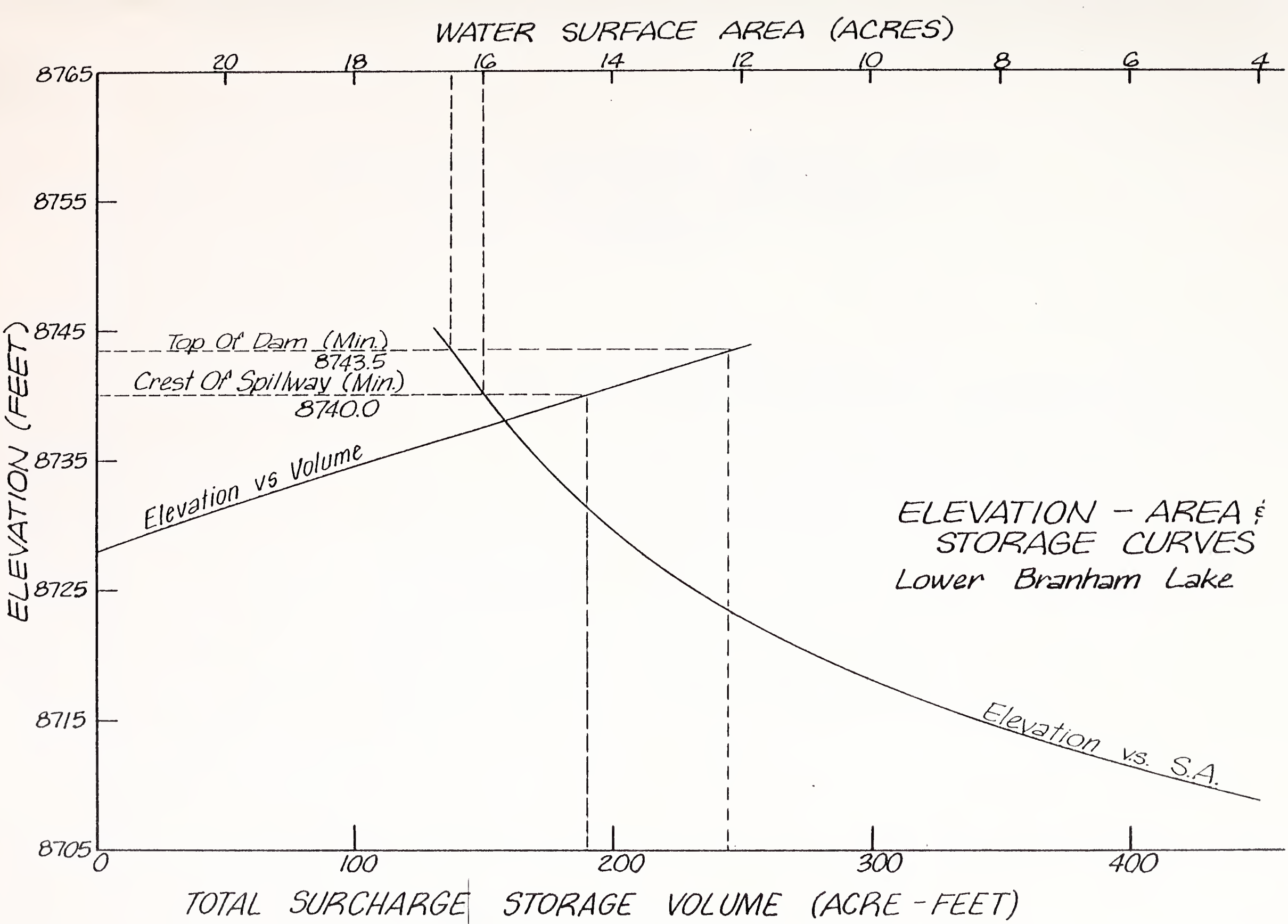


X-SECTION @ ℄ WEIR



TYPICAL X-SECTION SPILLWAY EXIT CHANNEL

PLATE 4



ELEVATION - AREA & STORAGE CURVES
Lower Branham Lake

PLATE 5

SPILLWAY DISCHARGE RATING CURVE
Lower Branham Lake Dam
Montana

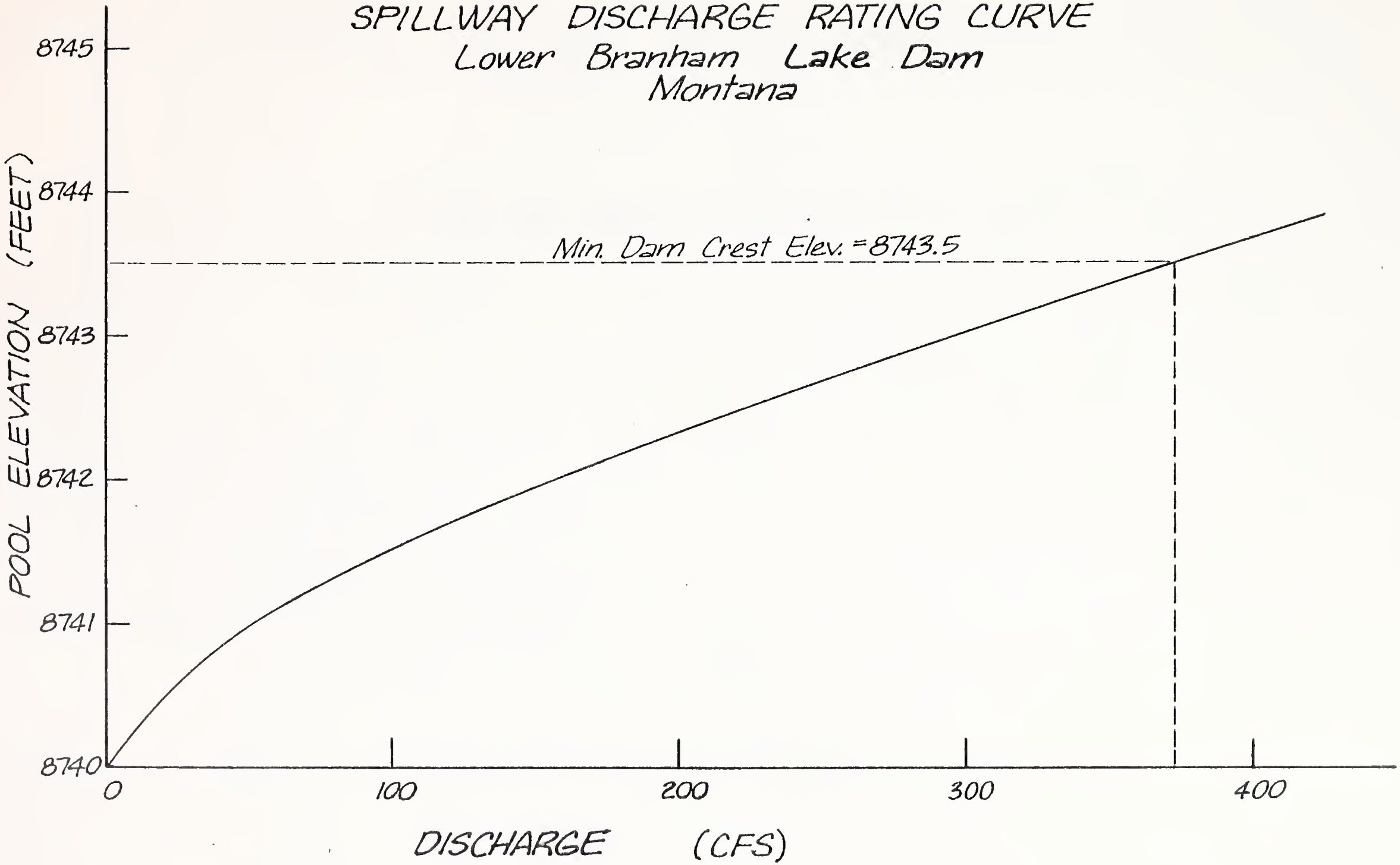


PLATE 6

18" Φ C.M.P. CONDUIT
OUTLET DISCHARGE RATING CURVE
Lower Branham Lake Dam

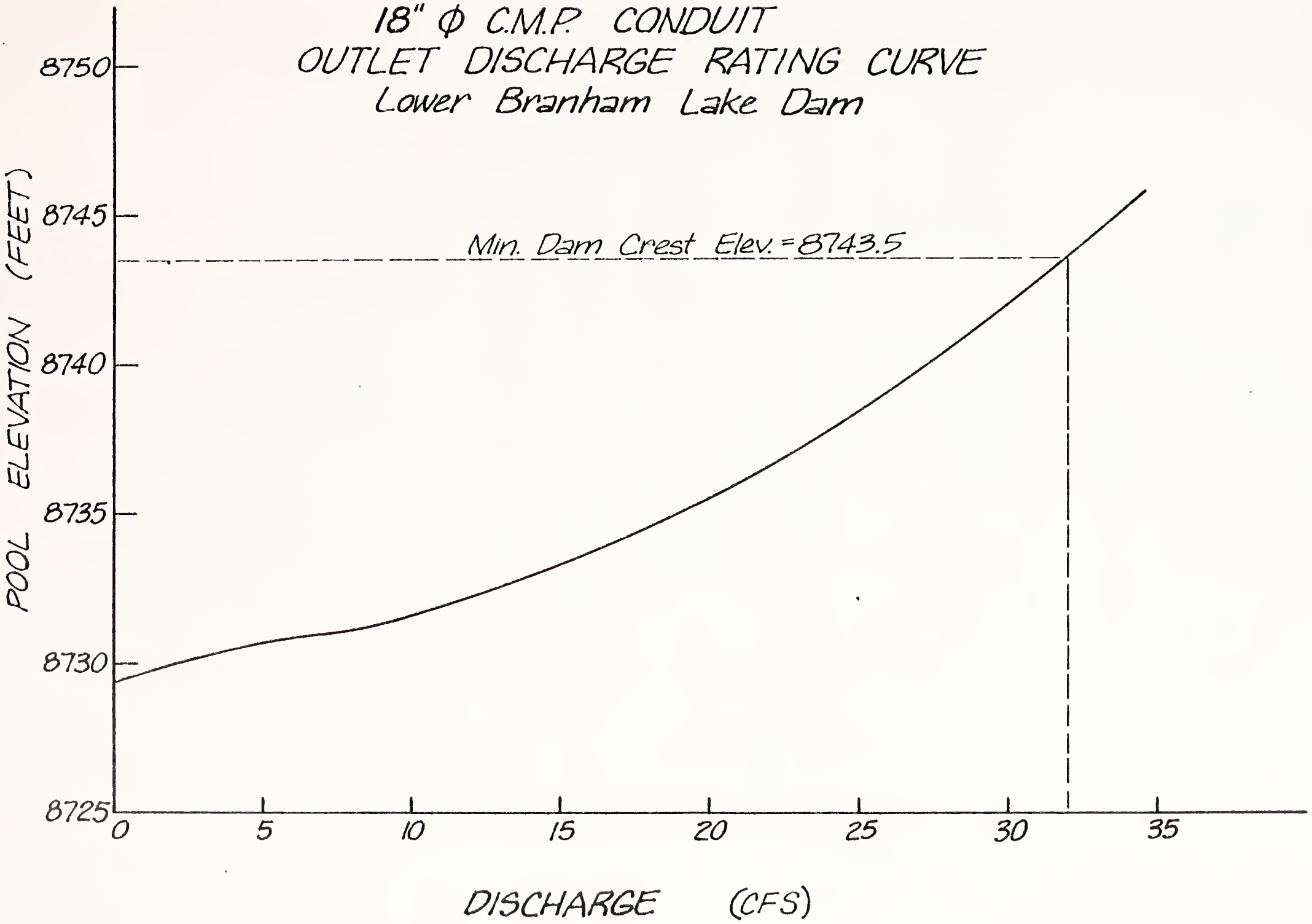


PLATE 7

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872

HELENA, MONTANA 59601

December 1, 1980

Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Attn: Ralph Morrison

Re: Hoskins-Western-Sonderegger, Inc. Dam Safety Inspection Report on Lower Branham Lake Dam (MT-898)

Dear Ralph:

We have reviewed the above referenced final draft report. We concur with the findings and recommendations and find that it satisfies the criteria of the Phase I report.

Minor editorial comments have been discussed with your staff, and we understand these will be incorporated in the final report.

Thank you for this opportunity to review and comment on the final draft report on Lower Branham Lake Dam.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB/AT/lj

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FOREST SERVICE
FEDERAL BUILDING MISSOULA, MONTANA 59801

NOV 2 6 1980
7530

Mr. Sidney Knutson, P.E.
Assistant Chief, Engineering Division
Corps of Engineers, Seattle District
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson:

We have reviewed the draft report of the Phase I inspection for Lower Branham Lake Dam and have the following comments.

As noted in the report, Lower Branham Lake Dam is in need of major restoration before water should be stored. In the interest of dam safety, the Forest Service has restricted storage until the permittee properly repairs the structure or renders it harmless by safely breaching it.

We find the consultant's hydrologic analysis of this structure unrealistic and certainly not of a caliber to conclude the dam is "unsafe". We agree a proper hydrologic analysis and flood routing is needed to yield design requirements for restoration of the structure commensurate with good engineering practice.

Sincerely,

Robert W. Larse

R. W. LARSE
Director
Engineering